WOOD STRESSED-SKIN PANELS: AN INVESTIGATION INTO THEIR BEHAVIOUR, LOAD DISTRIBUTION AND COMPOSITE PROPERTIES

Part 1: Review, modelling and design

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Doctor of Philosophy

2007

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CERTIFICATE OF AUTHORSHIP

I certify that the work in this thesis has not been previously submitted for a degree nor has it been submitted as part of requirements for a degree except as fully acknowledged within the text.

I also certify that the thesis has been written by me. Any help that I have received in my research work and the preparation of the thesis itself has been acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

Sydney, 28 March 2007

Christophe D. Gerber

ACKNOWLEDGEMENT

"Entre l'incroyance et la foi il n'y a qu'un souffle;
Entre l'état de doute et celui de certitude il n'y a qu'un souffle;
Sache chérir ce souffle si précieux car
C'est lui l'unique fruit de notre existence."

Khayyam Naishapuri,
astronome, mathématicien et poète persan (1048-1131)

Between 2002 and 2006, I have been undertaking my PhD project at the University of Technology, Sydney. Its completion would not have been possible without the contribution and expertise of many, whom I would like to thank here:

I would like to start with addressing many thanks to Prof. Keith Crews, my principal supervisor, for his support and expertise. With his experience and knowledge Keith's involvement has been valuable to my research. Many thanks also to Prof. Christophe Sigrist, my external co-supervisor and former fellow at SWOOD, who has been involved since the very concept of this project and contributed greatly to its concretisation, and to Prof. Bijan Samali, my internal co-supervisor.

During this research, the support and assistance from the laboratory staff have been fantastic. I want to thank them all for their contribution and for coping with me; especially when frustration took the better off me and my temper was getting short. While some of you have been on board for a short while, others have seen the whole research program through. So, I would like to thank Mario, David, Warwick, Ian, Rami, young Peter, and... I wish to dearly thank Setu, Laurence and Greg for getting the acquisition system of the test data working and for responding quickly and positively to interferences and breakdowns ...there is magic that science cannot explain! Last but surely not least and certainly not short of contribution and support: viele herzliche Danke Wolf für Deinen wunderbaren Einsatz, Deine Stimmung und Deine Freundschaft! Es hat mir echt Spass gegeben, mit Dir zusammenzuarbeiten aber auch mit Dir zu schwatzen. I am not certain the list is exhaustive so may the ones I have forgotten receive my sincerest apologies.

This research would not have been possible either without the financial support of the research commission "Académie suisse des sciences techniques" and the Faculty of Engineeing at UTS and without the outstanding participation, support and contributions from industry, that is, Trus Joist™, a Weyerhaeuser Business, Purbond AG (Collano Ebnöther AG), Kronoply AG, Paslode Austalia Ltd. and CADWORK. In particular, I would especially like to thank Mr Matt Stafford from Trus Joist™ and Mr Florian Stoffel from Purbond AG. TrusJoist™ supplied all the I-joists needed for the construction of the specimens and Purbond AG supplied custom-made polyurethane adhesive.

To my friends and/or colleagues at UTS and elsewhere I express my gratitude. I would like to acknowledge Joko for sharing his expertise with me. Un merci special à Laurent, de l'ENSAM à Cluny (France), pour son accompagnement lors de mes premier pas en éléments finis. Of course, there has been CFC ...thanks buddy for your companionship and great "in- and out-of-research" chitchats! Good luck with your own research ...and with your future endeavour! A vous tous mes amis au pays – en particulier Lisa, Willy et les petites – and to all of you ...wherever you are ...MERCI! ...THANK YOU! ...QUE DIEU VOUS GARDE!!! ...GOD BLESS YOU!!!

Pour terminer j'aimerais remercier ceux qui dans mon cœur occupe une place privilégiée. Mes plus reconnaissants et affectueux remerciements sont pour ma famille, tout spécialement mes parents. Vous m'avez témoigné un soutien infaillible et une confiance infinie, non seulement pour ce doctorat mais pour les entreprises qui ont jalonné mon parcours professionnel. Mes chers parents, je vous remercie de m'avoir laissé le libre choix ...et même si un sourire peut se dessiner parce que je n'ai pas choisi la ligne la plus droite pour arriver où je suis ...le voyage accompli m'a enrichi de rencontres et expériences merveilleuses! Vos encouragements m'ont été et me sont encore précieux et, votre affection et votre amour sont sans valeur. Je vous aime! ...j'ai encore une pensée toute spéciale et une gratitude énorme pour mon "chargé d'affaire" pour son application et efficacité. Il se reconnaîtra!

My last thought and lots of love go to the person who has suffered the most from the extreme dedication that completing this thesis has demanded. It has been hard to be my girlfriend ...I thank you for your support and love! I love you too!

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Gerber, C., Crews, K. & Sigrist, C. 2004, 'Investigation on Load/Stress Distribution in SSP and Composite Characteristics of SSP', *in Proceedings of 'The 18th Australasian Conference on the Mechanics of Structures & Materials'*, vol. 1, eds A.J. Deeks & H. Hao, A.A. Balkema Publishers, Perth (WA), Australia, pp. 77-83.

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ABBREVIATION AND KEY-TERM DEFINITIONS

AS	Australian Standard^{TM}
AS/NZS	Australian/New Zealand Standard^{TM}
CV	coefficient of variation
DOF	degree of freedom
EMC	equilibrium moisture content
FEA	finite element analysis
FEM	finite element model
LVDT	Linear Variable Differential Transducer
MOE	modulus of elasticity (Young's modulus)
MOR	modulus of rupture
PUR	one-component polyurethane
OSB	oriented strand board
RBA	rubber-based adhesive
SBT	simple beam theory
SLS	serviceability limit state
SSP	stressed-skin panel
ULS	ultimate limit state
UTS	University of Technology, Sydney, Australia

Strength axis: in an orthotropic panel, the axis showing the strongest strength

ABSTRACT

Stressed skin panels (SSPs) offer enhanced reliability and load-bearing capacity, potentially generating new opportunities for the use of timber in multi-storey residential, industrial, commercial and public buildings. However, in Australia, the design code for timber structures, AS 1720.1−1997 (Australian StandardTM 1997), does not make the most of the structural capabilities of this technology. In order to address this shortcoming, a major research project commenced in 2002 at the University of Technology, Sydney to investigate and quantify the structural performance of SSPs. This thesis details the research processes and outcomes from investigating the structural behaviours of SSP constructions. The project, which has emphasised that the sheathing and joists of SSP assemblies act compositely together, provides design recommendations that will ensure the safe and efficient design of SSP structures.

This PhD project focuses on the short-term behaviour of SSP structures subjected to quasi-static loading of serviceability and ultimate regime. The full-scale specimens are subjected to third-point loading (two uniformly distributed line loads) and centre-point loading (single uniformly distributed line load and concentrated point load). Effects of changing the physical integrity (skin discontinuities) and the boundary conditions (buckling restraint at the support) of the specimen are investigated. On the other hand, the long-term behaviour and specimen responses to and effects of in-plane loading, dynamic excitation, cyclic loading and loading history are outside the scope of this PhD research. Investigating multiple-span SSP systems and installing blockings inside the span are also excluded.

The experimental work involves full-scale testing of 27 simply supported single-span specimens, constructed in a variety of configurations and subjected to a series of non-destructive and destructive tests. This testing program enables the identification of the serviceability and ultimate responses, quantification of the two-way action, and characterising of the composite properties of SSP systems. It also permits quantification of the effects of discontinuing the skin and restraining buckling at the supports.

Two numerical models are developed within the framework of this project, that is, a mathematical procedure is derived from grillage theory and a finite element model is assembled using ANSYS software. Both models are capable of accurately predicting the serviceability responses of SSP structures.

This project puts forward design recommendations, culminating in the outline of a proposal to amend the Australian code for the design of timber structures (AS 1720). The current edition of this code, AS 1720.1−1997 (Australian Standard™ 1997), provides incomplete guidelines for the design of SSP systems. The recommendations offer Australian engineers a thorough and reliable design procedure for SSP systems.

FOREWORD

The author acknowledges the comments of the examiners. In general, only minor clarification and textual amendments have been required. Therefore, the thesis content, including the design recommendations and substantive conclusions, has not been affected by this editorial work.

The final thesis has been organised into two parts – Part 1: Review, modelling and design, and Part 2: Experimental work – in order to facilitate the legibility and accessibility of its content. Part 1 presents the literature and SSP technology review, the development and validation of two numerical models, and the design recommendations. Part 2 focuses on the laboratory investigation, introducing the testing program and presenting/discussing the test results. This organisational change required accommodating the introduction and conclusions of both parts.

A number of the examiners' comments address aspects/issues which are outside of the scope of the PhD project. The author, while appreciating the value of these comments, has been aware of most of these aspects/issues and, in the thesis, has proposed future work to address them.